

# QUANTITATIVE ASSESSMENT OF NOISE POLLUTION IN THE VICINITY OF PORT HARCOURT REFINING COMPANY, NIGERIA: A GEOSPATIAL ANALYSIS APPROACH

GBARATO, O. L.

Department of Physics  
Ignatius Ajuru University of Education  
Rivers State, Nigeria  
oliver.gbarato@iaue.edu.ng

## ABSTRACT

*The Port Harcourt Refining Company (PHRC) is a central component of Nigeria's oil-and-gas sector, refining crude oil into vital products and thereby contributing significantly to national energy security and economic development. Yet, its operations also entail substantial environmental burdens, among them noise pollution, which can impose serious health and well-being risks on workers and surrounding communities. This study aims to quantitatively assess noise-pollution levels around the PHRC oil-refinery complex in Rivers State, Nigeria, employing geospatial (GIS) methods to map sound-pressure distributions in the immediate area. Using a calibrated sound-level meter, we measured noise levels (dB (A)) at radial distances of 0 m (at the source), 5 m, 10 m, 15 m, 20 m, 25 m, 30 m, 35 m, 40 m, 45 m and 50 m from both PHRC New and Old plant units, at a consistent measurement height of 1.5 m above ground in accordance with ISO 8297: 1994. Geographical coordinates of each measurement point were collected, and contour maps of sound-pressure levels were generated using GIS software to identify spatial noise "hot-spots". Key findings reveal peak noise levels of approximately 105.8 dB (A) at the Old Plant's source point and 102.0 dB (A) at the New Plant, followed by a steady decline in intensity with distance. At 30 m radial distance, readings dropped to approximately 66-69 dB (A), and at 50 m to ~40 dB (A). Many points within 0-20 m of the plants exceeded Nigeria's industrial noise limit of ~85 dB (A) (National Environmental Standards & Regulations Enforcement Agency regulation) and therefore constitute high-exposure zones. GIS-based contour maps enabled clear visualisation of the spatial spread of noise, with the highest exposure zones clustered around the plant perimeters. These elevated noise levels carry important implications: for refinery workers, the risk of hearing damage, stress, and sleep disturbances is elevated; for nearby residential communities, the ambient noise may disrupt daily life, raise cardiovascular risk and reduce quality of life. From a policy perspective, the findings underscore the need for continuous monitoring of industrial noise, use of GIS mapping for targeted mitigation, and the development of comprehensive noise-management strategies in refinery contexts.*

*Keywords: Noise Pollution, Oil Refinery, Geospatial Analysis, Sound Pressure Levels, GIS Noise Mapping, Occupational Health.*

## Introduction

Petroleum refineries play a crucial role in the national economy through the processing of crude oil into valuable products such as gasoline, diesel, and jet fuel. These refined products are essential for transportation, industrial activities, and domestic use (Ite et al., 2013). The processes involved in this of crude oil into usable products are a significant industrial activity with substantial negative environmental implications. This is an indication that crude oil refinery, such as the Port Harcourt Refining Company (PHRC), emits various pollutants, including noise, which can have detrimental effects on the surrounding environment and human health. Putting this statement more succinctly shows that the Port

Harcourt Refining Company (PHRC), one of the largest refineries in Nigeria, is a critical component of the country's oil and gas sector, contributing significantly to its revenue and energy security. Specifically, the Port Harcourt Refining Company (PHRC), with a combined installed capacity of 210,000 bpd (comprising Old Refinery-60000 bpd and New Refinery-210000bpd) (Ogbuigwe, 2018), plays a pivotal role in Nigeria's oil and gas industry, contributing significantly to the national economy. Conversely, its operation has presented significant negative environmental consequences (Ogbuigwe, 2018; Ogbeide, 2015). The refinery's operations have raised environmental concerns, particularly regarding noise pollution. Prolonged exposure to high noise levels has been shown to result in adverse health effects, including hearing loss, stress, and sleep disturbances, impacting the well-being of the surrounding communities. Despite these known risks, there is a lack of comprehensive data on the extent of noise pollution in the vicinity of the PHRC and its impact on the environment and public health. Additionally, the application of geospatial analysis techniques to assess the spatial distribution of noise pollution in this area remains underexplored. This study aims to address these gaps by quantitatively assessing noise pollution levels around the PHRC using a geospatial analysis approach, providing valuable insights for policymakers and stakeholders to develop effective noise management strategies and protect the health of the local population.

Noise pollution, in particular, has become a major concern due to its adverse effects on human health and well-being. Noise pollution, also referred to as environmental noise or sound pollution, is the propagation of noise with a harmful impact on the activity of human or animal life (Aluko & Nna, 2015). The source of outdoor noise worldwide is mainly caused by machines, transport, and propagation systems. Poor urban planning may give rise to noise pollution. For instance, the practice of siting industrial installations side-by-side residential buildings can result in significant noise pollution. High noise levels can contribute to cardiovascular effects in humans and an increased incidence of coronary artery disease, while in animals, noise can increase the risk of death by altering predator or prey detection and avoidance, interfere with reproduction and navigation, and contribute to permanent hearing loss (Babisch et al., 2018).

This review has shown that noise pollution affects both health and behaviour. Unwanted sound (noise) can damage physiological health, causing hypertension, high stress levels, tinnitus, hearing loss, sleep disturbances, and other harmful effects. Sound becomes unwanted when it either interferes with normal activities such as sleeping, conversation, or disrupts or diminishes one's quality of life. Chronic noise exposure may cause noise-induced hearing loss. High noise levels can contribute to cardiovascular effects in humans, a rise in blood pressure, an increase in stress and vasoconstriction, and an increased incidence of coronary artery disease. In animals, noise can increase the risk of death by altering predator or prey detection and avoidance, interfere with reproduction and navigation, and contribute to permanent hearing loss. To support this assertion, Chen et al. (2017) conducted a cross-sectional study aimed at investigating the associations of noise exposure in an occupational setting with blood pressure and risk of hypertension by comparing 1,390 workers exposed to occupational noise with 1,399 non-exposed controls. This study found that workers exposed to high levels of occupational noise had significantly higher systolic and diastolic blood pressure, indicating that noise exposure was associated with elevated risk of hypertension (17.8% vs 9.0%). This supports the claim that noise contributes to cardiovascular effects like raised blood pressure. Lu et al. (2017) similarly conducted an experimental study to examine

whether noise exposure produced acute changes in cardiovascular responses, and whether these responses differed based on psycho-acoustic parameters to noises of low to high intensity. In this controlled experiment, 30 healthy young adults were exposed to industrial noise at different levels (< 55, 75, 90 dB). At 90 dB, there was a statistically significant increase in systolic blood pressure (SBP), and that increase in diastolic BP correlated with noise level. It was similarly observed that the psychoacoustic properties (tonality, fluctuation) of the sound influenced the magnitude of SBP change. Dimakopoulou et al. (2017) undertook a study to evaluate the association of exposure to aircraft and road traffic noise with the incidence of hypertension and other cardiovascular outcomes. The results conducted using 780 individuals indicated that long-term exposure to aircraft noise (especially night-time) is associated with incident hypertension, and possibly with other cardiovascular effects.

It has been shown from the above empirical studies that prolonged exposure to high noise levels can lead to hearing loss, stress, sleep disturbances, and other health issues (Basner et al., 2014). In these studies, noise pollution measurements and possible effects on public health were conducted with the aim of analyzing noise pollution levels in major areas, highlighting the importance of accurate measurement techniques for effective assessment. This revelation shows that noise pollution is a common issue in industrial areas, resulting from machinery, industrial processes, and transportation. For this and many other reasons, noise pollution has become a global issue affecting urban and industrial areas worldwide. Studies on noise pollution and its impacts provide valuable insights into effective management and control strategies to protect public health and the environment. These efforts include the adoption of geospatial analysis, which has emerged as a vital tool in environmental assessment, allowing researchers to map and analyze the spatial distribution of pollutants, including noise. By utilizing Geographic Information Systems (GIS) and remote sensing technologies, geospatial analysis enables the identification of areas with high levels of noise pollution and the assessment of its impact on the environment and human health (Longley et al., 2015; Akintuyi et al., 2014).

Hence, Geospatial analysis is a powerful tool for assessing the spatial distribution of environmental pollutants, including noise (Murphy & King, 2014). Wawa & Mulaku (2015) measured noise at selected points in Nairobi's Central Business District (CBD), then created a noise map using the Geographic Information System (GIS) to identify hotspots. They found average noise levels between 61-78 dB, with variation across the CBD. Majidi & Khosravi (2016) evaluated traffic noise in Zanjan, Iran, using GIS to determine noisy areas, and adopted the use of noise mapping and indices. The finding was that many of the sampling stations showed high traffic-noise annoyance levels, using measures like TNI (Traffic Noise Index). Monazzam et al. (2015) assessed spatial changes in traffic noise pollution in Tehran, Iran, using the Geographic Information System (GIS). The findings from this study showed that the average equivalent sound level was higher than the national standard limit at all stations. Motealliemi et al. (2016) undertook the collection of noise measures (equivalent sound level, maximum levels, etc.) in summer and fall, then GIS was used to prepare zoning (noise mapping) for the district, showing how noise is distributed spatially. These studies have highlighted the importance of GIS-based mapping for effective noise pollution assessment and management.

A sound wave is a type of mechanical wave that propagates through a medium due to the vibration of particles. The propagation of sound waves can be described by a set of physics equations that relate to the wave's frequency, wavelength, speed, and amplitude. The

acoustic pressure for a plane simple harmonic wave travelling in the negative x-direction can be represented using the equation

$$P(x, t) = P_{max} (2\pi t - Kx) \quad (1)$$

Where  $p(x,t)$  is the acoustic pressure, representing the instantaneous difference between the local pressure and the ambient pressure, and  $P_{max}$  is the pressure amplitude

The speed of sound in a medium is given by the equation

$$v = \sqrt{\frac{B}{\rho}} \quad (2)$$

Where  $B$  is the bulk modulus of the medium, and  $\rho$  is the density of the medium. Similarly, the wavelength,  $\lambda$ , speed of sound,  $v$ , and sound frequency,  $f$ , are related by the equation

$$\lambda = c/f \quad (3)$$

An overview of the key physical principles underlying sound generation in industrial settings is essential for understanding and managing noise pollution in these environments.

Sound generation in industrial settings is a complex phenomenon that involves various physical processes, with the primary source of sound in these environments being the vibration of machinery and equipment, which can be caused by mechanical forces, fluid dynamics, or electromagnetic interactions. Mechanical vibrations, usually caused by rotating parts, such as motors and turbines, or by impact forces, such as hammering or drilling, are the common sources of sound in industrial settings. The frequency and amplitude of these vibrations determine the characteristics of the sound produced. Fluid dynamics play a significant role in sound generation in industrial settings, especially in processes involving high-speed air or fluid flow. Turbulence and cavitation can generate significant noise levels, as can the interaction of fluid flow with solid surfaces (Munson et al., 2006). In some industrial processes, electromagnetic interactions can generate sound. For instance, transformers and other electrical equipment can produce a humming noise due to the vibration of magnetic components (Griffiths, 2013). Acoustic resonance can amplify sound in industrial settings, especially in enclosed spaces or in the presence of resonant structures, and increase noise levels in specific frequency ranges (Kinsler et al., 1999).

Propagation of emitted sound in industrial settings is influenced by the environment, including the presence of obstacles, reflective surfaces, and absorptive materials. The interaction of sound waves with these elements can affect the distribution of sound emitted in the workplace (Pierce, 1989). These factors interact in complex ways to influence the propagation of environmental sounds. Understanding these factors is crucial for accurate noise modeling and prediction in various applications, such as urban planning, environmental impact assessments, and noise control strategies. For instance, temperature, humidity, and wind speed can significantly affect sound propagation. Temperature gradients, for example, can cause sound refraction, leading to changes in the direction of sound waves. Humidity affects the absorption of sound, with higher humidity levels generally leading to less absorption and thus further propagation of sound waves. The physical features of the landscape, such as hills, valleys, and buildings, can affect sound propagation. These features can cause reflection, diffraction, and scattering of sound waves, altering the path and intensity of the sound as it travels. The type of ground surface (grass, concrete, water) can influence sound propagation. Hard surfaces like concrete reflect sound, while softer surfaces like grass absorb emitted sounds. The ground's impedance, which is related to its ability to absorb sound, also plays a role in sound propagation. Objects in the path of sound waves, such as buildings, trees, or walls, can obstruct and scatter sound, affecting its propagation.

The size, shape, and material of the obstacle will determine the extent of the effect. High-frequency sounds tend to be absorbed more readily by the atmosphere and are more susceptible to barriers and obstacles, whereas low-frequency sounds can travel longer distances and are less affected by barriers.

### Materials and Methods

The Port Harcourt Refining Company (PHRC) is located in Alesa, in the Eleme Local Government Area (LGA), Rivers State, in the South-South region of Nigeria. Eleme Local Government Area is one of the 23 LGAs of Rivers State, with its headquarter in Ogale. The region experiences a tropical rainforest climate, with distinct wet and dry seasons. High annual rainfall (multi-thousand mm) and warm, humid temperatures are typical. The elevation is generally lowland, often around 20-30 meters above sea level in many parts of the region. The dominant land uses within the study area include residential communities, industrial facilities (notably the PHRC refinery complex, which lies approximately 25 km east of Port Harcourt city), upstream and downstream oil and gas operations, and port facilities, such as the Onne Port Complex. There has been significant urbanization and land use change in Eleme and adjacent LGAs, with the expansion of built-up areas, infrastructure, and industrial zones. The presence of heavy industrial infrastructure (refining units, boilers, generators, process units) suggests potential for multiple noise sources: operational machinery, flares, vehicle traffic (raw material input, product output), and utilities.

The Sound Pressure Levels were measured with the aid of the Sound Level Meter (SLM) within the plant (at 0.00m) and at radial distances of 5.00m, 10.0m, 15.0m, 20.0m, 25.0m, 30.0m, 35.0m, 40.0m, 45.0m, and 50.0m away, respectively. The Sound Level measurements were taken at heights of 1.5m above normal ground (ISO 8297: 1994).

Contour maps of the measured noise levels from the sources at each of the radial distances for the different locations were drawn by measuring the noise levels at the centre of each of the refining plants within the study area. The geographical positions at radial distances of 5.0m, 10.0m, 15.0m, 20.0m, 25.0m, 30.0m, 35.0m, 40.0m, 45.0m, and 50.0m away from each of the noise sources were similarly recorded. The noise level and geographical positions established within the sources and at radial distances away were then joined up to form a contour map of the emitted noise level.

### Results and Discussion

The results of the sound level measurements and noise mapping at the PHRC New and Old plants and their geographical positions are presented in Tables 1 and 2 below.

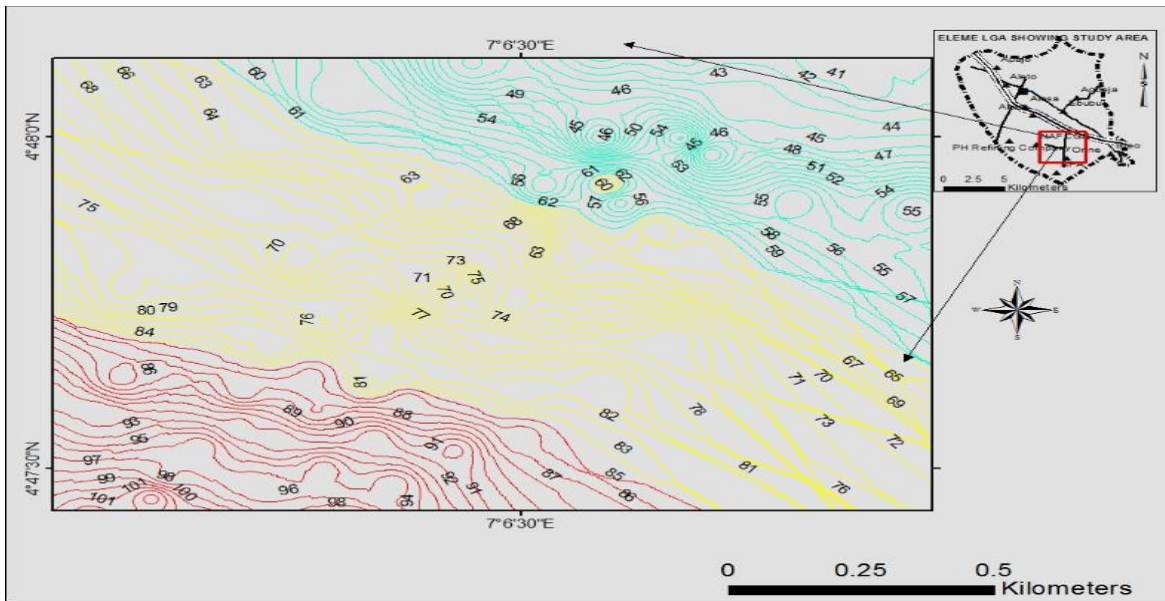
**Table (1): Sound Levels and Geographical Positions at the PHRC New Plant**

Distance (m)	Geographical Position		Sound Level <i>dB(A)</i>
	Latitude	Longitude	
0.00	N 04 <sup>0</sup> 47' 25.3"	E007 <sup>0</sup> 06' 03.90"	102.00
	E007 <sup>0</sup> 06' 03.90"	N 04 <sup>0</sup> 47' 25.3"	
5.00	N 04 <sup>0</sup> 47' 29.50"	E007 <sup>0</sup> 06' 08.50"	95.80
	E007 <sup>0</sup> 06' 03.90"	N 04 <sup>0</sup> 47' 25.3"	
10.00	N 04 <sup>0</sup> 47' 33.90"	E007 <sup>0</sup> 06' 12.90"	91.30
	E007 <sup>0</sup> 06' 03.90"	N 04 <sup>0</sup> 47' 25.3"	
15.00	N 04 <sup>0</sup> 47' 38.30"	E007 <sup>0</sup> 06' 17.20"	85.50
	E007 <sup>0</sup> 06' 03.90"	N 04 <sup>0</sup> 47' 25.3"	

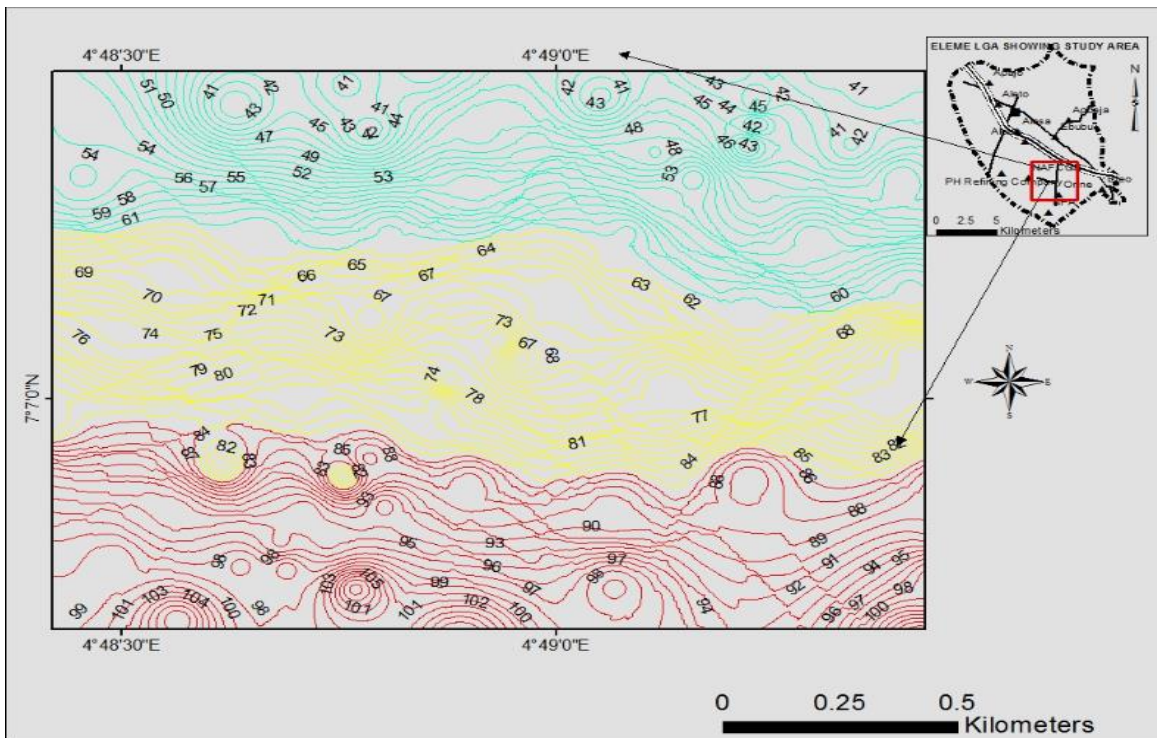
20.00	N 04 <sup>0</sup> 47' 42.50"	E007 <sup>0</sup> 06' 21.70"	80.90
	E007 <sup>0</sup> 06' 03.90"	N 04 <sup>0</sup> 47' 25.3"	
25.00	N 04 <sup>0</sup> 47' 46.90"	E007 <sup>0</sup> 06' 26.20"	75.20
	E007 <sup>0</sup> 06' 03.90"	N 04 <sup>0</sup> 47' 25.3"	
30.00	N 04 <sup>0</sup> 47' 51.10"	E007 <sup>0</sup> 06' 30.80"	69.30
	E007 <sup>0</sup> 06' 03.90"	N 04 <sup>0</sup> 47' 25.3"	
35.00	N 04 <sup>0</sup> 47' 55.70"	E007 <sup>0</sup> 06' 35.30"	62.80
	E007 <sup>0</sup> 06' 03.90"	N 04 <sup>0</sup> 47' 25.3"	
40.00	N 04 <sup>0</sup> 47' 59.90"	E007 <sup>0</sup> 06' 39.70"	55.10
	E007 <sup>0</sup> 06' 03.90"	N 04 <sup>0</sup> 47' 25.3"	
45.00	N 04 <sup>0</sup> 48' 04.20"	E007 <sup>0</sup> 06' 44.20"	43.20
	06' 03.90"	N 04 <sup>0</sup> 47' 25.3"	
50.00	N 04 <sup>0</sup> 48' 07.90"	E007 <sup>0</sup> 06' 48.90"	40.10
	06' 03.90"	N 04 <sup>0</sup> 47' 25.3"	

**Table (2): Sound Levels and Geographical Positions at the PHRC Old Plant**

Distance (m)	Geographical Position		Sound Level <i>dB(A)</i>
	Latitude	Longitude	
0.00	N 04 <sup>0</sup> 48' 33.90"	E007 <sup>0</sup> 06' 41.70"	105.80
5.00	N 04 <sup>0</sup> 48' 38.30"	E007 <sup>0</sup> 06' 46.20"	98.30
	E007 <sup>0</sup> 06' 41.70"	N 04 <sup>0</sup> 48' 33.90"	
10.00	N 04 <sup>0</sup> 48' 42.70"	E007 <sup>0</sup> 06' 50.70"	93.70
	E007 <sup>0</sup> 06' 41.70"	N 04 <sup>0</sup> 48' 33.90"	
15.00	N 04 <sup>0</sup> 48' 47.10"	E007 <sup>0</sup> 06' 55.10"	88.30
	E007 <sup>0</sup> 06' 41.70"	N 04 <sup>0</sup> 48' 33.90"	
20.00	N 04 <sup>0</sup> 48' 51.70"	E007 <sup>0</sup> 06' 59.70"	81.70
	E007 <sup>0</sup> 06' 41.70"	N 04 <sup>0</sup> 48' 33.90"	
25.00	N 04 <sup>0</sup> 48' 56.10"	E007 <sup>0</sup> 07' 04.90"	73.90
	E007 <sup>0</sup> 06' 41.70"	N 04 <sup>0</sup> 48' 33.90"	
30.00	N 04 <sup>0</sup> 49' 00.50"	E007 <sup>0</sup> 07' 09.20"	66.50
	E007 <sup>0</sup> 06' 41.70"	N 04 <sup>0</sup> 48' 33.90"	
35.00	N 04 <sup>0</sup> 49' 04.90"	E007 <sup>0</sup> 07' 13.70"	60.40
	E007 <sup>0</sup> 06' 41.70"	N 04 <sup>0</sup> 48' 33.90"	
40.00	N 04 <sup>0</sup> 49' 09.50"	E007 <sup>0</sup> 07' 18.20"	53.80
	E007 <sup>0</sup> 06' 41.70"	N 04 <sup>0</sup> 48' 33.90"	
45.00	N 04 <sup>0</sup> 49' 13.90"	E007 <sup>0</sup> 07' 22.70"	47.30
	E007 <sup>0</sup> 06' 41.70"	N 04 <sup>0</sup> 48' 33.90"	
50.00	N 04 <sup>0</sup> 49' 18.50"	E007 <sup>0</sup> 07' 27.30"	40.20
	E007 <sup>0</sup> 06' 41.70"	N 04 <sup>0</sup> 48' 33.90"	



**Fig. (1):** GIS Mapping of measured noise levels at the PHRC New Plant



**Fig. (2):** Mapping of Measured Noise Levels at the PHRC Old Plant

The present study’s sound-level measurements around the PHRC New and Old plants reveal a clear and expected trend. Noise intensity declines with increasing distance from the source, yet at the plant perimeters and immediate surroundings, the levels remain very high and often exceed permissible limits. Beginning with the PHRC New Plant (Table 1), the sound pressure levels (in dB(A)) were measured at various radial distances from the central point of the source. At the source (0.00 m), the recorded level was 102.00 dB(A). At 5.00 m it dropped to 95.80 dB(A); at 10.00 m it was 91.30 dB(A); at 15.00 m 85.50 dB(A); at 20.00 m 80.90 dB(A); at 25.00 m 75.20 dB(A); at 30.00 m 69.30 dB(A); at 35.00 m 62.80 dB(A); at 40.00 m 55.10 dB(A); at 45.00 m 43.20 dB(A); and at 50.00 m 40.10 dB(A). From this, we see the mean over

the measured points (0-50 m) is approximately  $\sim 73.37$  dB(A) (simple arithmetic mean of listed levels). The range is from 102.00 dB(A) down to 40.10 dB(A), and variance would reflect wide dispersion-high levels near the source, steep drop-off with distance.

Table 2 summarises the PHRC Old Plant noise measurement results. At 0.00 m the level was 105.80 dB(A); at 5.00 m 98.30 dB(A); at 10.00 m 93.70 dB(A); at 15.00 m 88.30 dB(A); at 20.00 m 81.70 dB(A); at 25.00 m 73.90 dB(A); at 30.00 m 66.50 dB(A); at 35.00 m 60.40 dB(A); at 40.00 m 53.80 dB(A); at 45.00 m 47.30 dB(A); and at 50.00 m 40.20 dB(A). The mean across these measured points is approximately 73.85 dB(A). The range runs 105.80 dB(A) down to 40.20 dB(A).

A careful comparison of the measurement results from the two plants shows that the maximum level measured at the Old Plant (105.80 dB(A)) exceeded that of the New Plant (102.00 dB(A)), indicating the Old Plant has a slightly higher peak noise emission. At 50m, the levels are nearly equal (40.10 dB(A) New, 40.20 dB(A) Old), indicating that far-field decay brings levels down to similar values. The average measured over the points is quite similar ( $\sim 73.4$  vs  $\sim 73.9$  dB(A)), suggesting that overall dispersion and attenuation behave in a comparable fashion, though peak emissions differ. The Old Plant shows consistently slightly higher values at every comparable distance, which may suggest either less effective noise mitigation, older equipment, or different operations.

Figures 1 and 2 (the GIS-based contour maps) illustrate this spatial distribution visually: concentric zones of decreasing decibel values radiate from each plant. Hot-spots (red zones) appear within the plant fences and immediate perimeters (0–15 m), particularly prominent at the Old Plant site. As we move beyond a 30 m radius, the colour contours shift through yellow to green and eventually blue, indicating lower noise. The visualisation allows easy identification of zones where noise exposure is highest and where mitigation should be targeted.

Finally, comparing the measured noise levels with regulatory standards: The National Environmental Standards and Regulations Enforcement Agency (NESREA) Regulations (S.I. No. 35, 2009) set maximum permissible noise levels for industrial premises/continuous or intermittent noise: for a factory/workshop, the limit is 85 dB(A) for 8 hours daily exposure. For general “industrial (outside perimeter fence)” areas, the daytime limit under the general environment table is 70 dB(A). In this study, the measured values at many points exceed these limits: both plants registered well above 85 dB(A) at the source and 5–10 m distances. For example, 0 m at Old Plant: 105.80 dB(A) (which is 20.8 dB above the 85 dB limit). Even at 20 m distances in both plants ( $\sim 81$ – $80$  dB(A)) are still above 70 dB(A). The results, therefore, indicate exceedance of permissible levels and a clear need for noise attenuation measures.

The high noise levels recorded at both the Port Harcourt Refining Company (PHRC) Old and New plants confirm that industrial refining operations can generate sound exposures well above accepted environmental norms. The peak levels measured (105.8 dB(A) at the Old plant, 102.0 dB(A) at the New plant) place workers at the refinery and residents living close by in potentially harmful sound environments. Previous research on industrial and traffic noise has documented similar concerns of this nature. For example, in a GIS-based traffic noise study in Tehran, by Monazzam et al. (2015), the maximum equivalent sound level reached 84.2 dB(A) in a busy highway district, and the average was above the national standard limit. That the measured values at the PHRC exceed those urban road-noise benchmarks underscores the severity of the noise burden in this industrial context.

For workers at PHRC, prolonged exposure to sound over 100 dB(A) is associated with well-known risks including hearing loss, tinnitus, elevated stress, and sleep disturbance (Basner et al., 2014). For nearby communities, the elevated levels close to the plant (>80 dB(A) within 20 m) mean that ambient sound is significantly above typical residential exposure limits (often 55–65 dB(A) daytime). The health implications thus extend beyond occupational zones into surrounding residential zones, where residents may suffer annoyance, sleep interruption, elevated blood pressure or cardiovascular strain. A study of aircraft and road traffic noise found long-term exposure linked to incident hypertension (Dimakopoulou et al., 2017). These findings align with that body of work—the sound levels at PHRC are high enough to warrant concern.

The clear trend of attenuation, noise levels steadily declining from the source outward (from ~105 dB(A) at 0 m down to ~40 dB(A) at 50 m), is consistent with fundamental physics of sound propagation (equations for wave speed, wavelength, amplitude) and environmental acoustics (ground absorption, vegetation, temperature, humidity, distance). In industrial settings, sound attenuation is influenced by obstacles, barriers, ground impedance, and atmospheric conditions (Pierce, 1989). The data from this study show exactly this: close to the source, the levels are extreme; as distance increases, the effect of distance and environment causes a drop-off. This pattern echoes findings in other geospatial noise mapping studies. For instance, a GIS noise map of Nairobi's CBD found noise levels ranged from 61 dB(A) up to 78 dB(A), with clear spatial variation and hotspots around high-traffic zones (Wawa & Mulaku, 2015). The use of GIS contour mapping in this study therefore, adds value by visualising exactly where the noise “hot-spots” are, similar to other research, and helps refine mitigation targeting.

From a policy and management perspective, the results suggest an urgent need for noise-control interventions at PHRC and surrounding communities. For workers, hearing conservation programmes, use of personal hearing protective equipment, and monitoring of occupational noise exposures are essential. For neighbouring residents, creation of buffer zones, acoustic barriers (earth berms, dense vegetation), relocation of sensitive receptors, and stricter enforcement of ambient noise limits should be considered. The spatial maps generated allow targeting of the “hot-zones” (0–20 m radius) for priority action.

### **Summary, Conclusion, and Recommendation**

The study found that noise levels around the PHRC New and Old plants decrease steadily with distance from the source, as seen in the drop from ~105 dB(A) at the plant perimeter to ~40 dB(A) at a distance of 50 m. Importantly, several measurement points, particularly those close to the plants, exceeded regulatory noise limits (for example, above the ~85 dB(A) industrial exposure threshold). These results illustrate both the spatial extent of noise propagation and the zones of highest risk.

This shows that the operations of the PHRC refinery complex clearly contribute significantly to local noise pollution, creating elevated sound-exposure conditions for workers and for communities in the immediate vicinity. These elevated levels pose real environmental and public-health risks, including hearing damage, sleep disturbance, and cardiovascular stress. The spatial noise, contour maps generated in this study, demonstrate the value of GIS-based assessment in identifying “hot-spots” of exposure and guiding targeted mitigation. Continuous noise monitoring, ideally combined with geospatial analysis, is essential in industrial settings like this to inform management and protect health.

From the findings of this study, it is recommended that the implementation of a rigorous maintenance schedule for machinery and transport vehicles be encouraged, ensuring that worn equipment or misaligned components, which often generate excess noise, are repaired or replaced promptly. Enforcement and monitoring of noise-exposure limits for workers, including the use of appropriate personal protective equipment (PPE), rotation of staff to reduce continuous exposure in high-noise zones, and maintaining ambient noise logs, should be made.

By implementing these noise-control measures, the refinery not only protects worker health and community well-being but also advances broader goals of environmental sustainability and occupational safety. Mitigating noise pollution in industrial hubs like PHRC contributes to healthier ecosystems, improved quality of life, and sustainable industrial development in Rivers State and beyond.

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